CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Microplastics Regulatory Efforts

2020 Forum on Environmental Accreditation

Scott Coffin, Ph.D.

Research Scientist III

Regulatory Development Unit

Division of Drinking Water

State Water Resources Control Board

LIFE

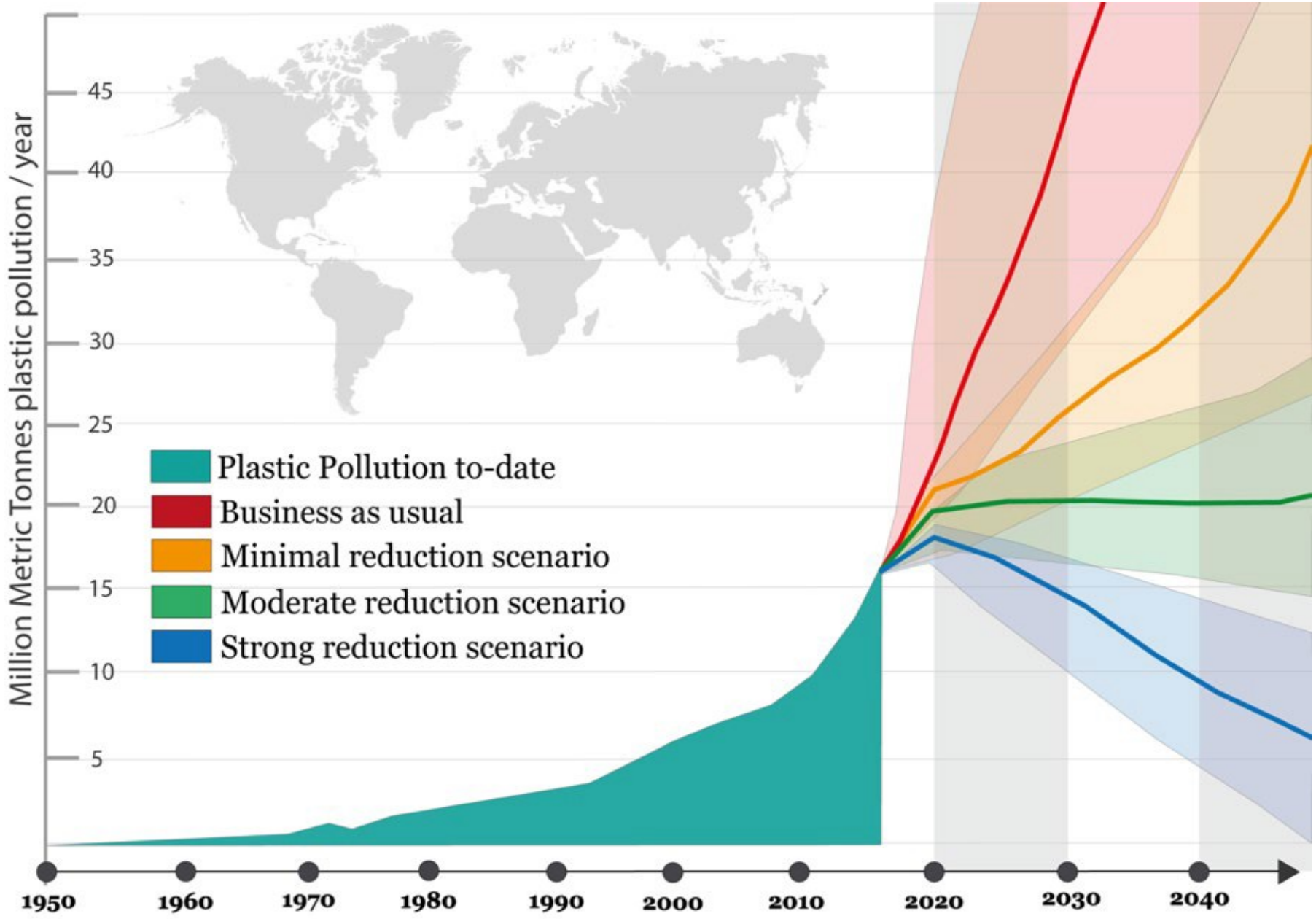
Throwaway Living

DISPOSABLE ITEMS CUT DOWN HOUSEHOLD CHORES

Photo: LIFE magazine (1955)

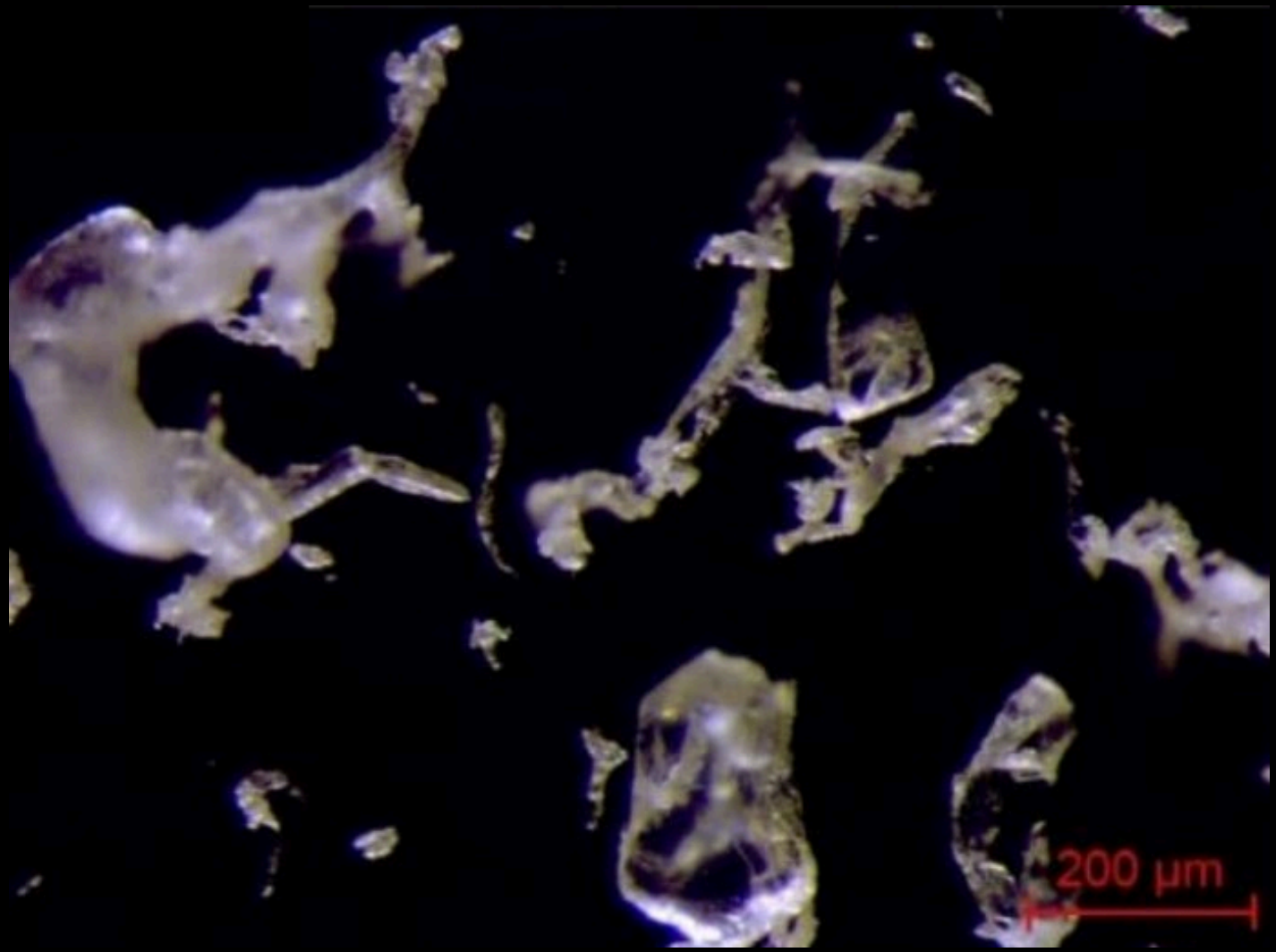

PHOTO BY GREG

Plastic generation *may* double by 2030



Data from Geyer et. al, *Science Advances* 2017

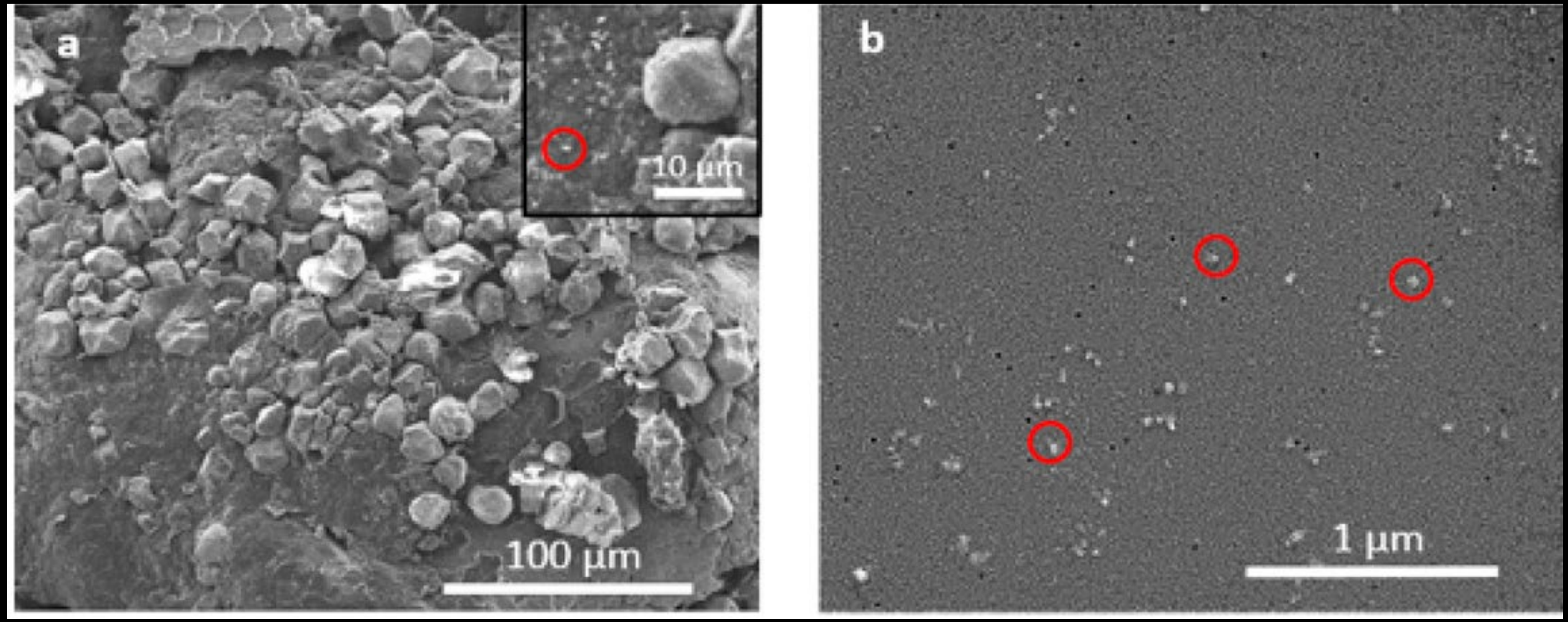
Plastic fragments after entering environment



Polyethylene mechanically weathered with sand for 80 days. Optical light microscopy image.

Hepsø , *Environmental Science & Technology,* 2018.

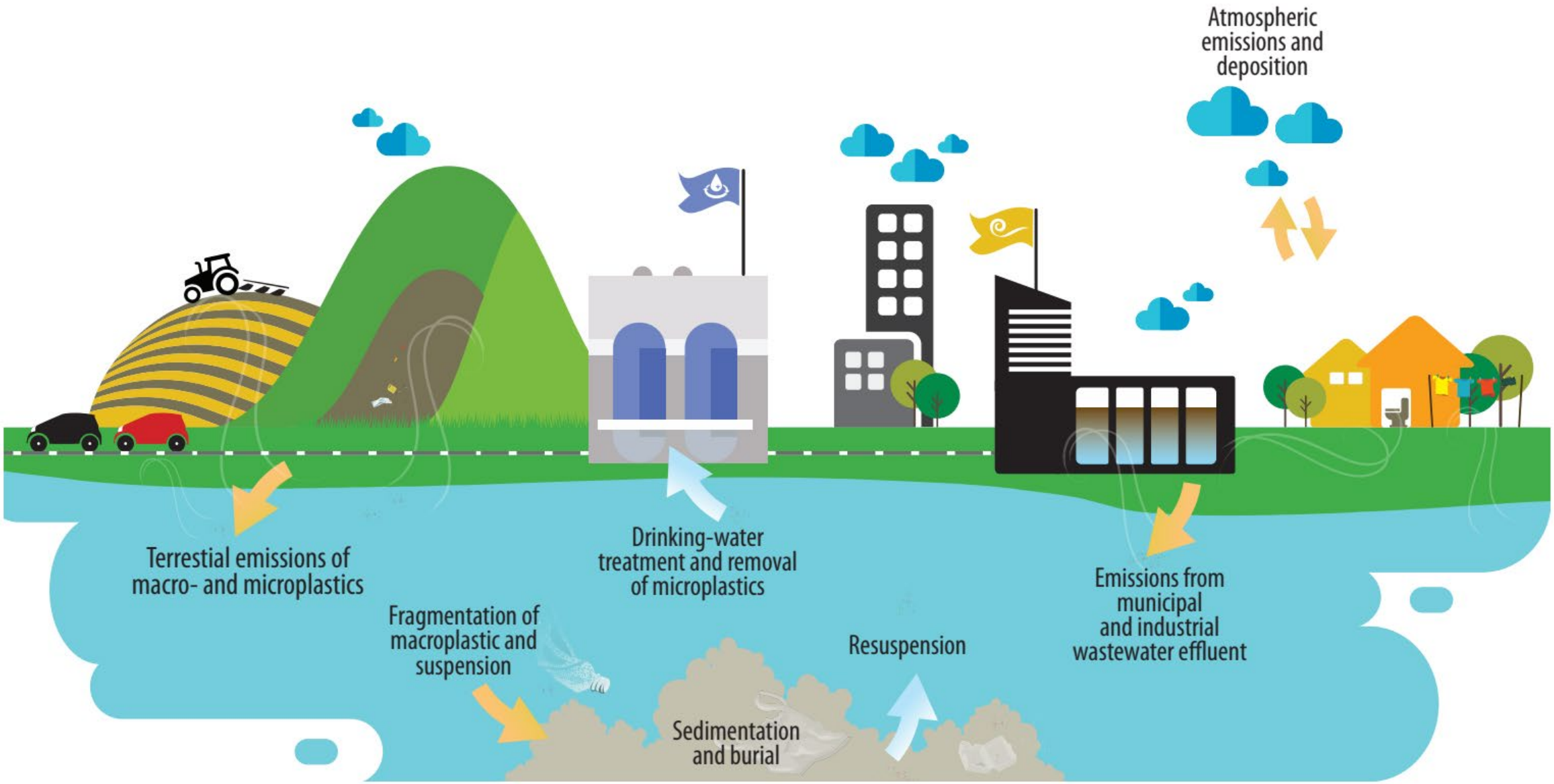
Microplastic degrades into nanoplastic



Scanning electron microscopy image of polyethylene facial scrub

[1]Hernandez et. al, *Environmental Science & Technology* 2017

Plastic breaks down and enters surface water



World Health Organization (2019)

Senate Bill 1263 passed in 2018

Deadlines

December 31 ,2021

- Initiate Statewide Microplastics Strategy

December 31, 2025

- Develop **risk assessment** framework
- Develop standardized **methods**
- Establish baseline **occurrence** data
- Investigate **sources** and **pathways**
- Recommend **source reduction** strategies

Senate Bill 1422 passed in 2018

Deadlines

July 1,2020

- State Water Board must **define** microplastics in drinking water

July 1,2021

- Adopt **standard analytical method**(s)
- Adopt requirements for four years of **testing** and public disclosure of results
- Consider issuing a **notification level** or other guidance
- **Accredit** laboratories

Senate Bill 1422 passed in 2018

Deadline

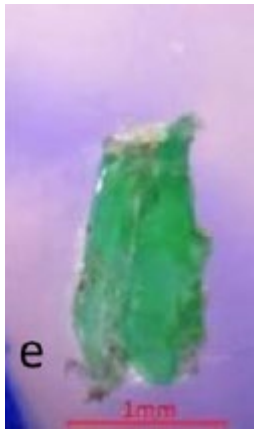
July 1,2020

- State Water Board must **define** microplastics in drinking water

Microplastics is a diverse contaminant suite

Polymer
- PP
- LDPE
- HDPE
- PVC
- PU
- PET
- PS
- ABS
- PMMA
- POM
- PBT
- PC
- PA
- SAN
- PEEK
- PSU
- PU
- ...

Additives
- Plasticizers
- Colorants
- Reinforcements
- Fillers
- Flame retardants
- Stabilizers
- ...

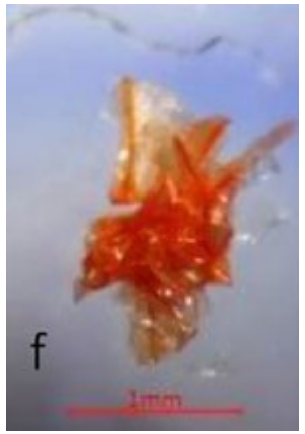


Product types

Primary
- Pre-production pellets
- Personal care products
- Industrial abrasives...

Secondary
- Agricultural materials
- Beverage bottles
- Carry bags
- Construction materials
- Containers
- Clothing
- Cutlery
- Electronics
- Food packaging
- Film
- Furniture
- Insulation
- Mattresses
- Medical
- Pillows
- Pipes
- Textiles
- Toys
- Tires
- ...

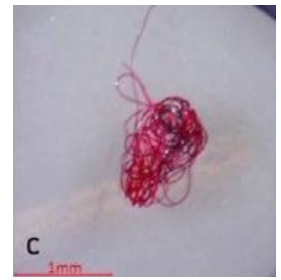
Size
- <5mm
- ...
- Nano
- ...



Morphology
- Fiber
- Fiber bundle
- Fragment
- Sphere
- Pellet
- Film
- Foam
- ...

Colour
- Red
- Orange
- Yellow
- Tan
- Brown
- Off white
- White
- Grey
- Blue
- Green
- ...

Eco-toxins
- PAHs
- PCBs
- DDT
- Heavy metals
- PBDEs
- ...



Rochman, et al. *Environmental toxicology and chemistry* (2019)

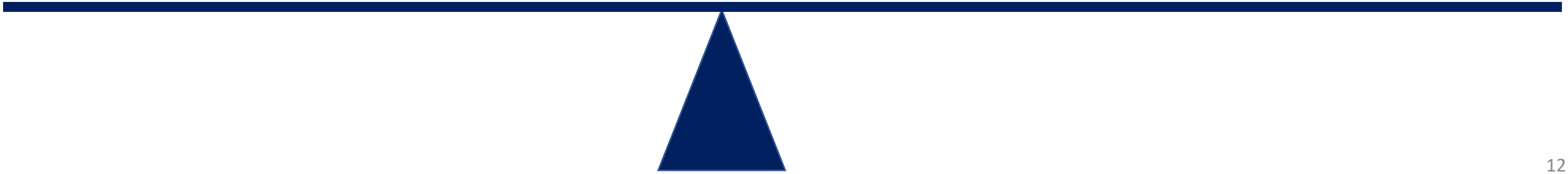
Microplastics definition: principal considerations

Characteristics

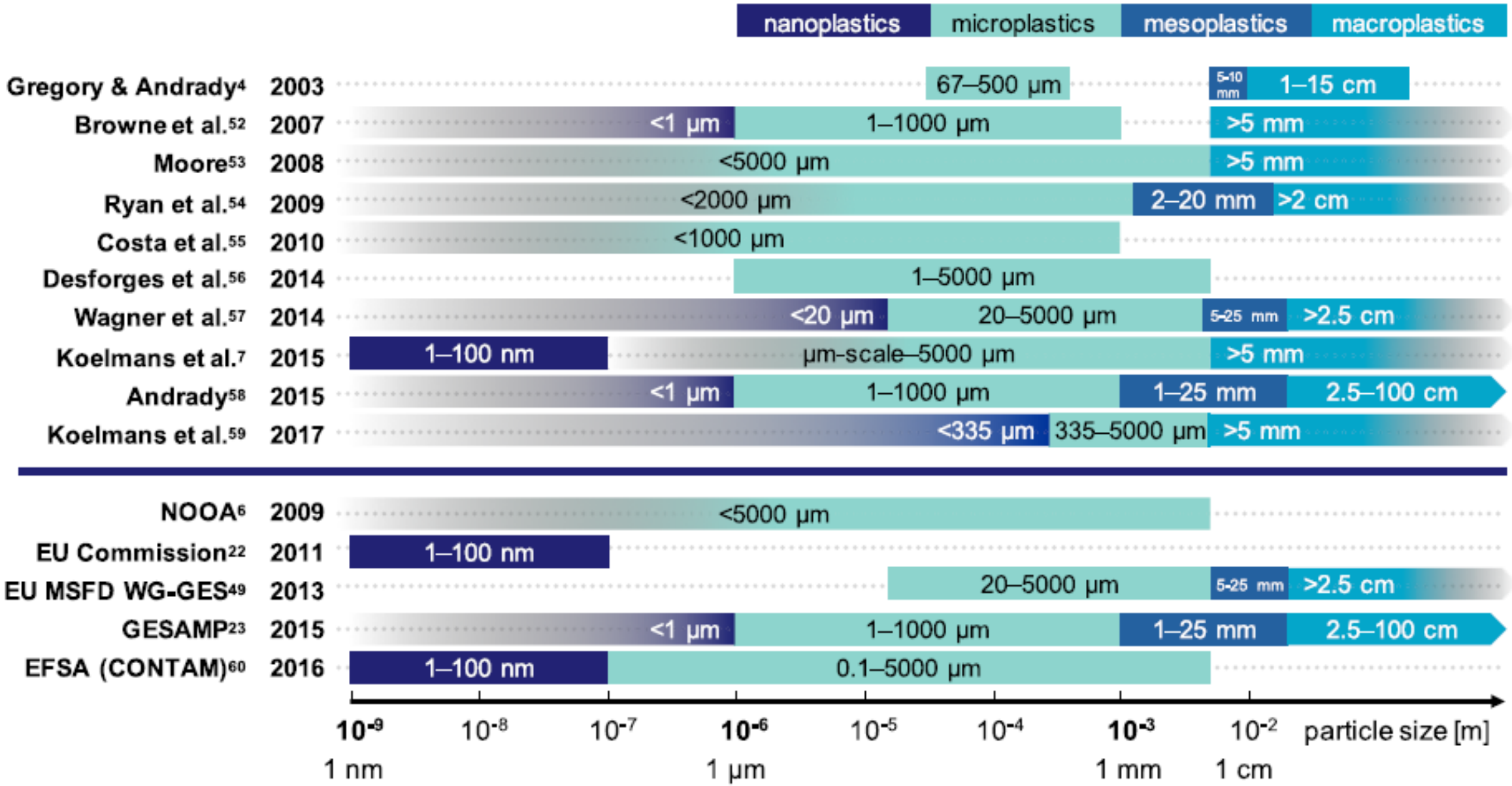
- Chemical composition
- Physical state (solid,gel)
- Size
- Solubility
- Shape & structure
- Color
- Degradability?

Relevance/Limitations

- Human health impacts
- Occurrence
- Technical feasibility
- Cost

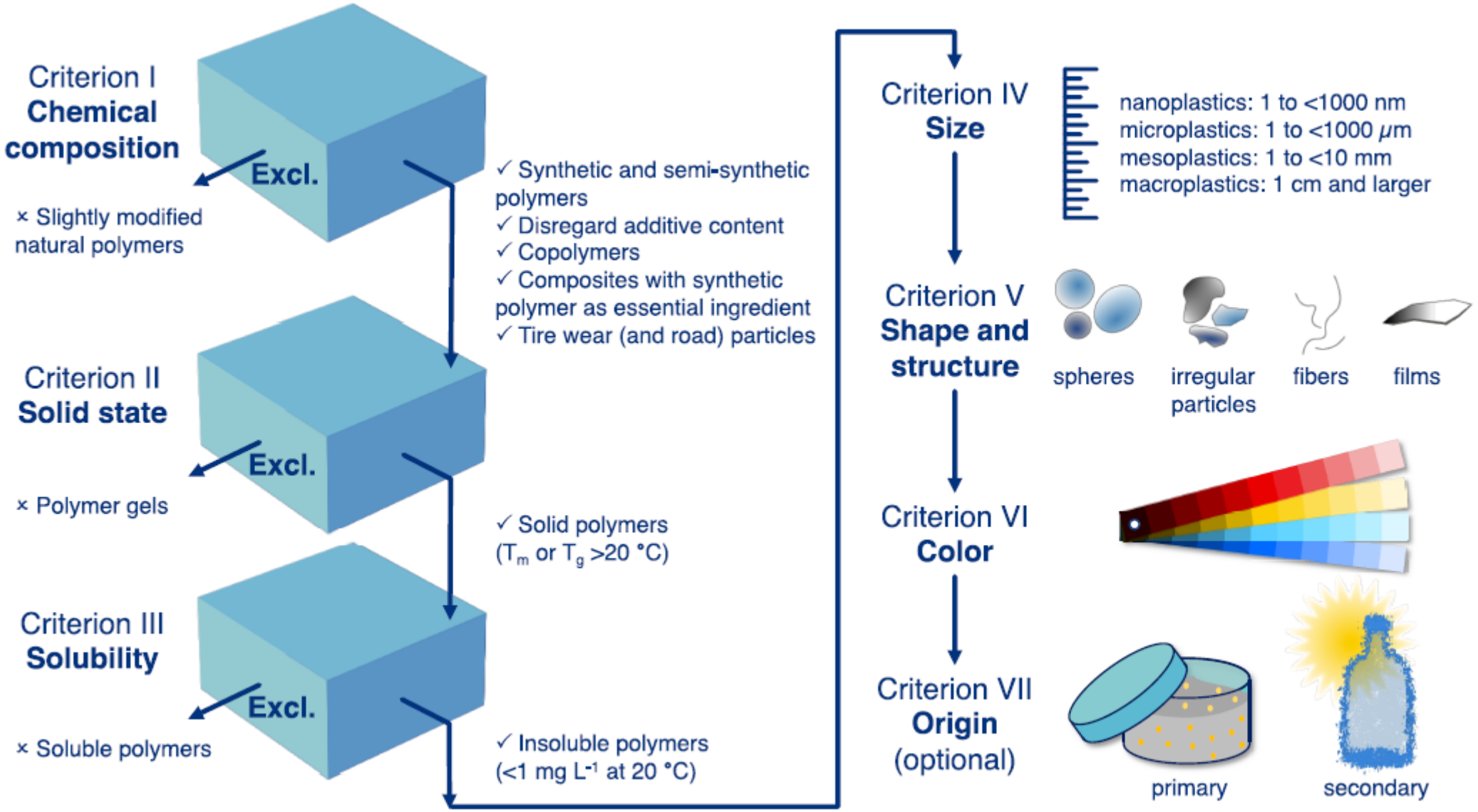


Microplastics size definition: no consensus



Environ. Sci. Technol. 2019, 53, 1039−1047

Proposed definition and categorization framework



Environ. Sci. Technol. 2019, 53, 1039−1047

Definition of microplastics in drinking water

Timeline

30-Day Public Comment period

- April-May, 2020

Board Adoption

- Prior to July 1, 2020

(Potential) reconsideration public comment period

- April- May, 2021

(Potential) reconsideration by Board

- Prior to July 1, 2020

Senate Bill 1422 passed in 2018

Deadline

July 1,2021

- Consider issuing a **notification level** or other guidance

Notification level = health-based advisory level established by the State Water Board for chemicals in drinking water that lack maximum contaminant levels (MCLs). Requires timely notification if exceeded.

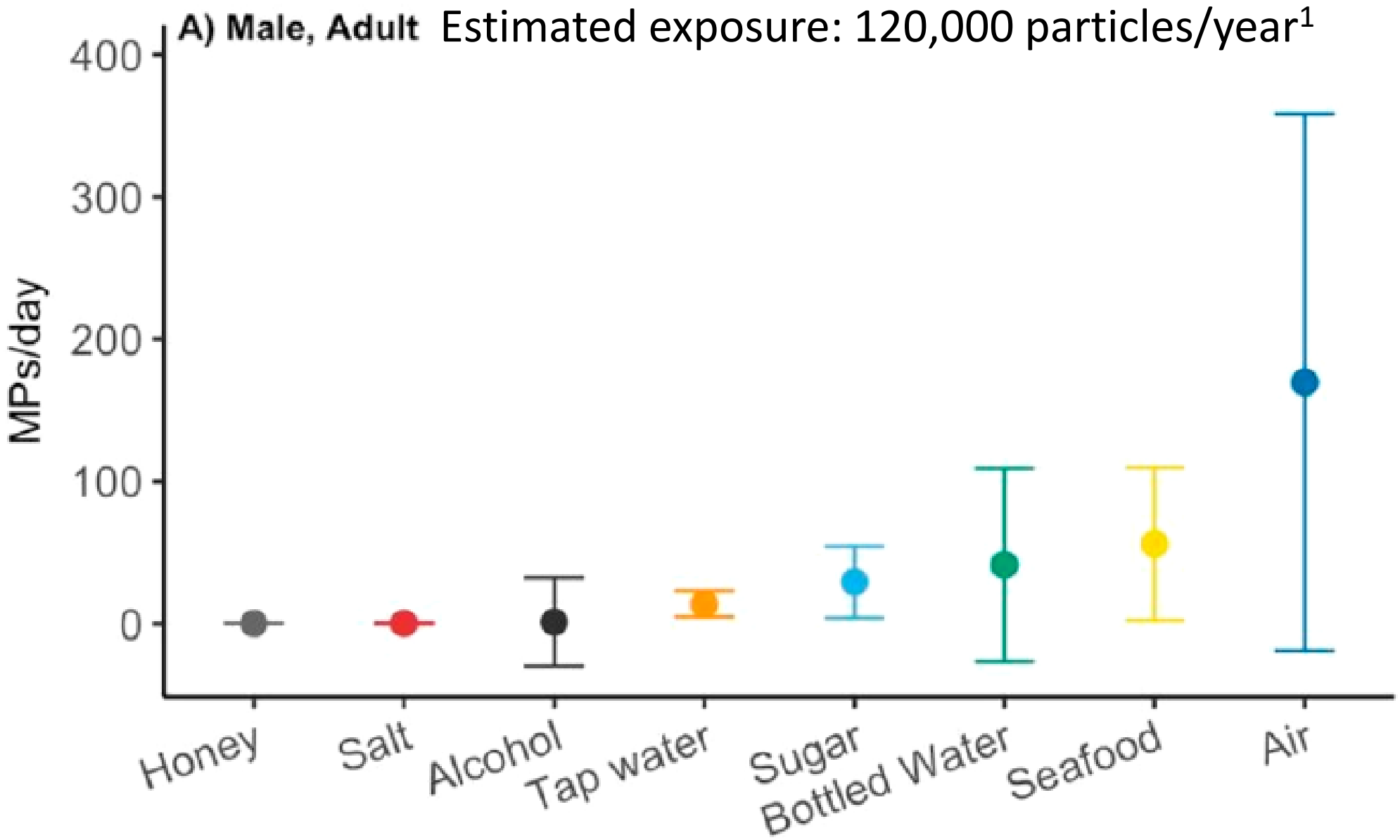
Are humans at risk of from microplastic?

Hazard ✖ **Exposure** = **Risk**

Potential to cause harm

Probability to cause harm

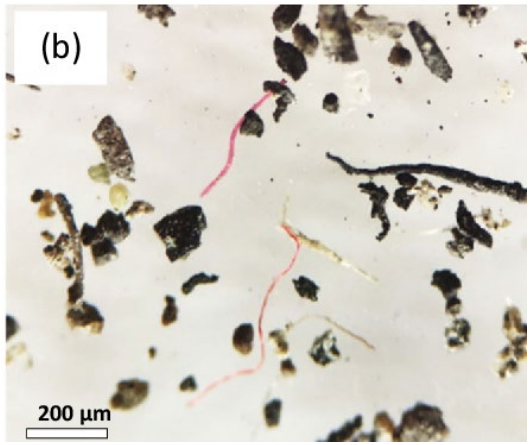
Some exposure routes to microplastics known



[1]Cox, *et al, Environmental Science & Technology*, 2019

Microplastics are in indoor and outdoor dust

- **Household dust** is 2.6% microplastic (range: 1.5-13%) [1]
- **Indoor** (23 g/kg) > outdoor (1.6 g/kg)[1]
- **Fibers** dominate (~88%)[1]



Microfiber in dust[2]

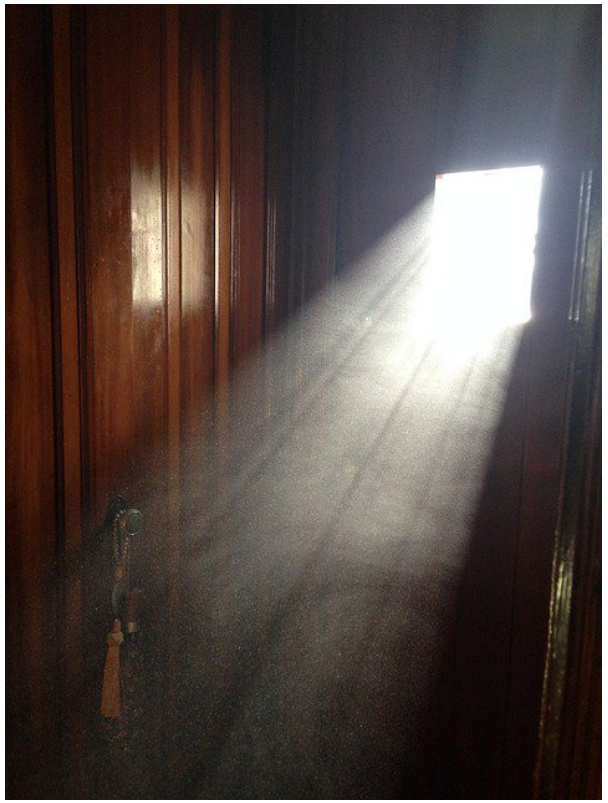
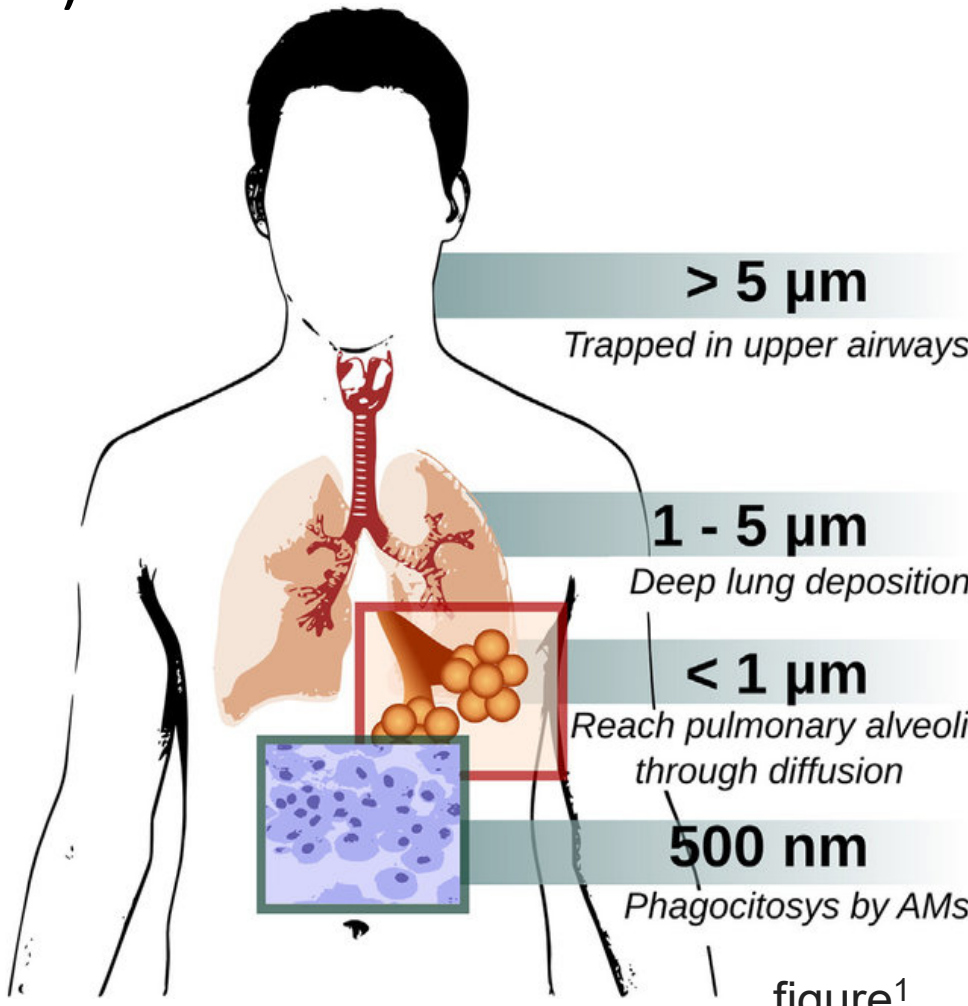


Image: @HaggardHawks



figure[1]

[1]C. Liu et al, *Environment International* 2019

[2]Dehgani et al., *Environmental Science and Pollution Research* 2017

Microplastics fall onto food from dust

- Ingest ~250 grams of plastic/year[1]
- 100-500x more ingestion of microfibers via **dust fall** than **mussels**[2]
- **Major data gaps** for commonly consumed items (meat, dairy, grains, vegetables)[1]

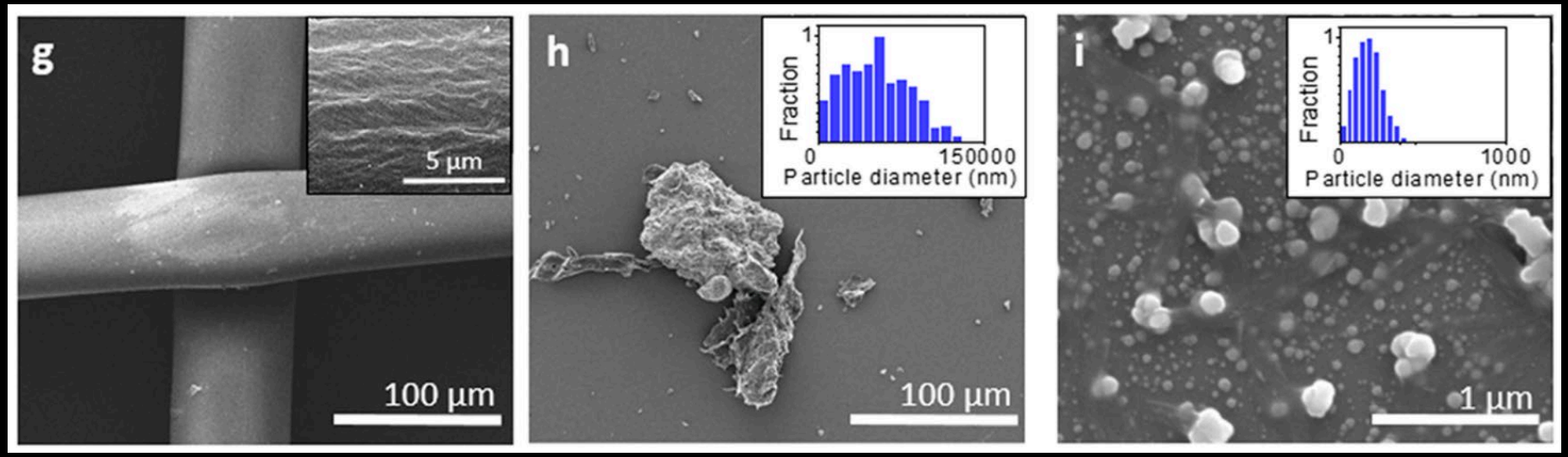
Humans eat ~250 grams of plastic/year[1]

Photo: Reuters

[1]Cox, *et al, Environmental Science & Technology*, 2019

[2]Catarino, *et al*, *Environmental Pollution*, 2018

Plastic Teabags Release Millions of Microplastics



Teabag steeped at 95°C releases ~2.3 million microplastics, and ~14.7 billion nanoplastics

Hernandez et. al, *Environmental Science & Technology* (2019)

Plastic is a cocktail of contaminants

Photo from Rios et al. (2007), Marine Pollution Bulletin.

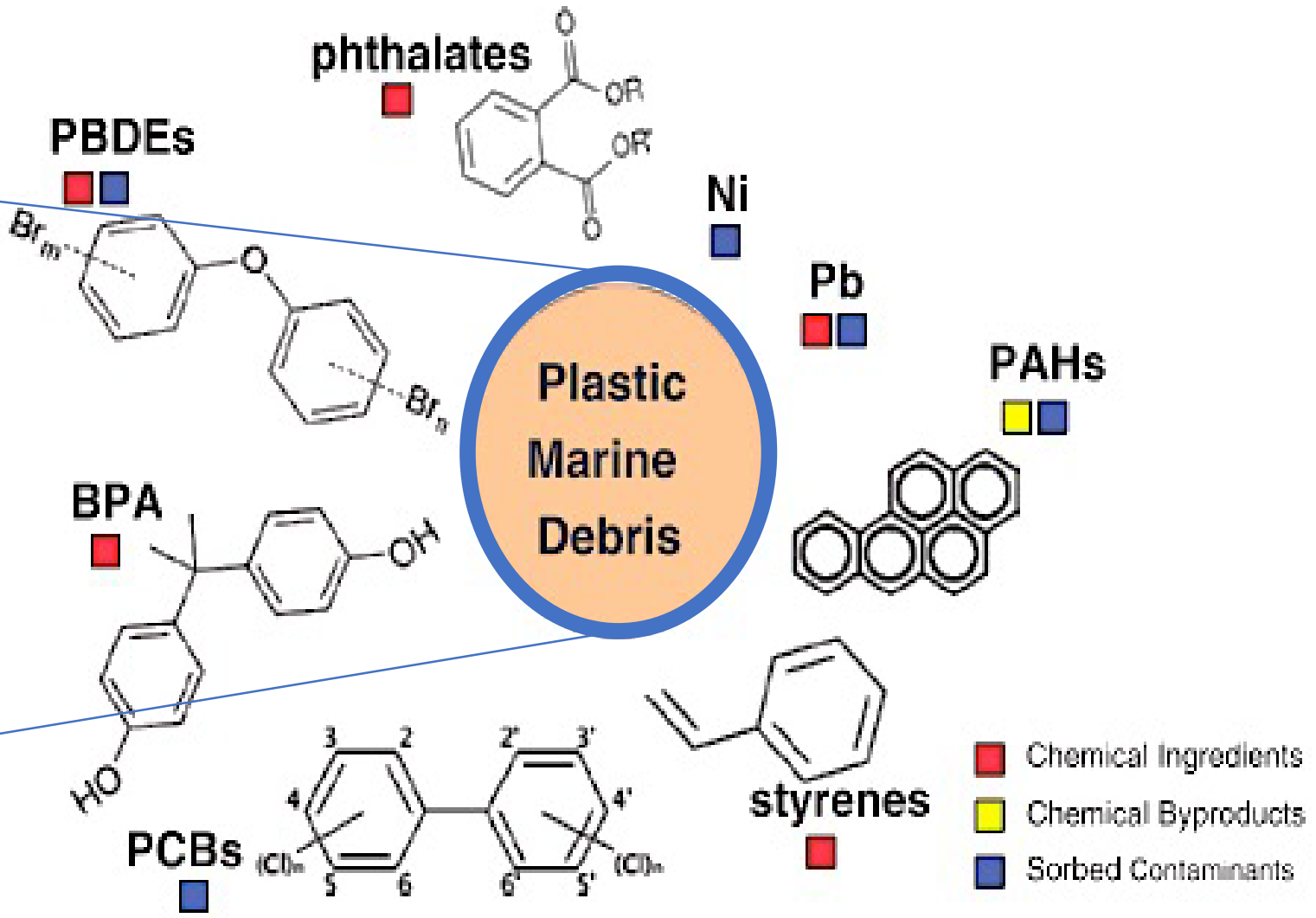
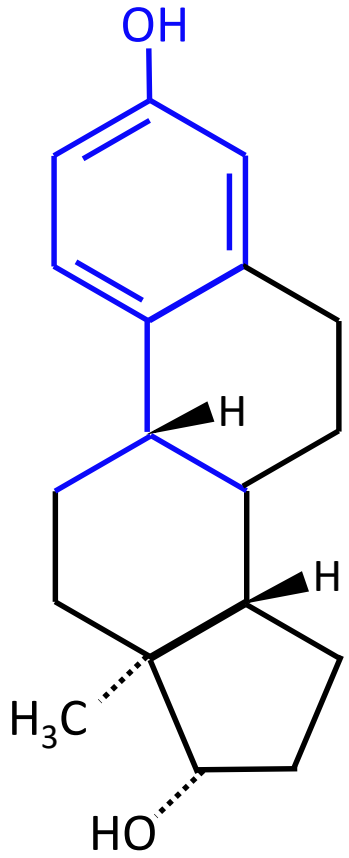


Figure from Bergmann et al. (2015), Marine Anthropogenic Litter.

Some plastic additives are endocrine disruptors

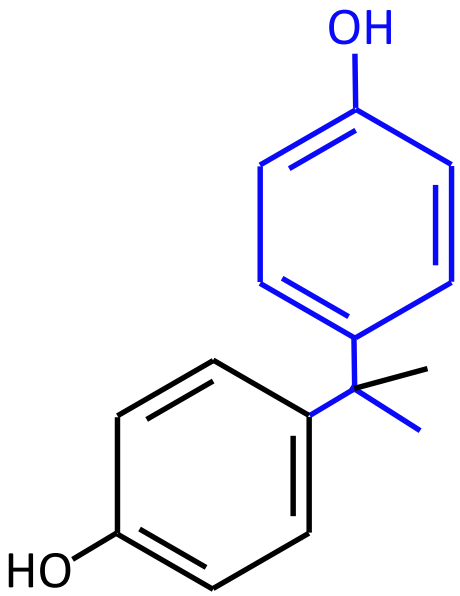
Estrogen

Endogenous Hormone

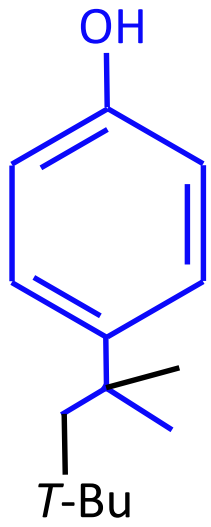


17-β-estradiol

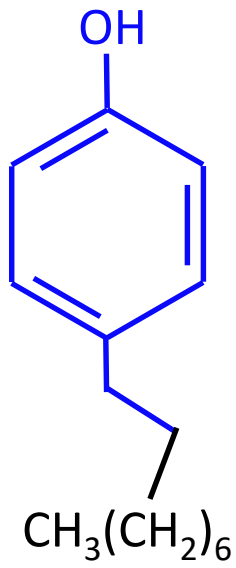
Common Plastic Additives



Bisphenol A



4-*tert*-octylphenol

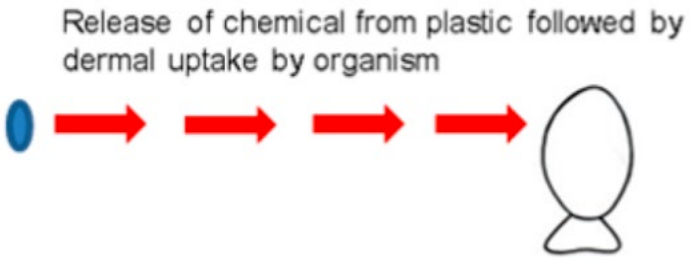


4-n-nonylphenol

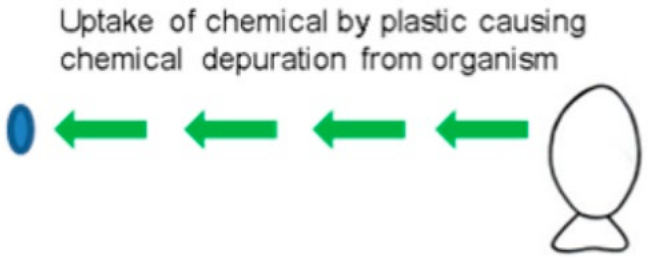
Figure: Coffin (2018)

Microplastics *can* transfer chemicals

- Plastic may **transport** chemicals[1]



- Plastic may act as **cleaning mechanism** for chemicals[1]



- Adsorption/desorption kinetics depend on **gut residence**, steady state[1]

$$C_{\mathrm{PLR},t} = \frac{k_1 C_{\mathrm{PL}}^{\mathrm{Ing}} - k_2 C_{\mathrm{L},t}^{\mathrm{Ing}}}{k_1 + \frac{M_{\mathrm{PL}}}{M_{\mathrm{L}}} k_2} \left(1 - e^{-\left(k_1 + \frac{M_{\mathrm{PL}}}{M_{\mathrm{L}}} k_2\right) \mathrm{GRT}_t}\right)$$

[1]Koelmans, et. al, *Environmental Science & Technology* (2016)

Environmental Science & Technology

Article

Cite This: *Environ. Sci. Technol.* 2019, 53, 4588−4599

pubs.acs.org/est

Fish and Seabird Gut Conditions Enhance Desorption of Estrogenic Chemicals from Commonly-Ingested Plastic Items

Scott Coffin,*[,†] Guo-Yong Huang,*[,‡] Ilkeun Lee,[§] and Daniel Schlenk[†]

Transfer of chemicals unlikely to cause risk to humans

Table 3.2 Exposure assumptions to assess microplastic intake in drinking-water, along with rationale and associated level of conservatism

Parameter	Assumption	Rationale	Level of conservatism
Chemical concentrations in microplastic	Highest reported[a]	Upper-bound concentrations measured, although data are limited to marine microplastics.	High: concentrations often vary over several orders of magnitude and concentrations of contaminants in marine microplastics may be much higher than in fresh water since they will have longer to equilibrate. For some of the studies there was a three-fold difference in concentration between the highest and second highest value and more when compared with a mean.
Leaching/ bioavailability of the chemical contaminant in the body	100%	In the absence of information on leaching in the GI tract, complete release is assumed.	Very high: release from plastics is complex; more information on extraction with gut fluid would help refine this assumption.

World Health Organization (2019)

Transfer of chemicals unlikely to cause risk to humans

Chemical[a]	Upper bound concentration in microplastic (µg/g)	Maximum daily intake (ng/kg bw/day)[b]	Point of departure (µg/kg bw/day)	Margin of exposure (MOE)	Conclusion
Bisphenol A	0.7297	0.001	609	5.9×10^8	No safety concern
Cadmium	3390	5.0	0.8	1.7×10^2	No safety concern
Chlordane	0.0144	0.00002	50	2.5×10^9	No safety concern
Di(2-ethylhexyl)phthalate	0.0699	0.0001	2500	2.5×10^{10}	No safety concern
Dichlorodiphenyltrichloroethane	7.1	0.0001	1000	1.0×10^8	No safety concern
Hexachlorobenzene	0.0587	0.00002	50	6.0×10^8	No safety concern
Polyaromatic hydrocarbons	119	0.06	100	6.0×10^5	No safety concern
PBDEs	9.9	0.01	100	7.2×10^6	No safety concern
PCBs	18.7	0.03	5	1.9×10^5	No safety concern

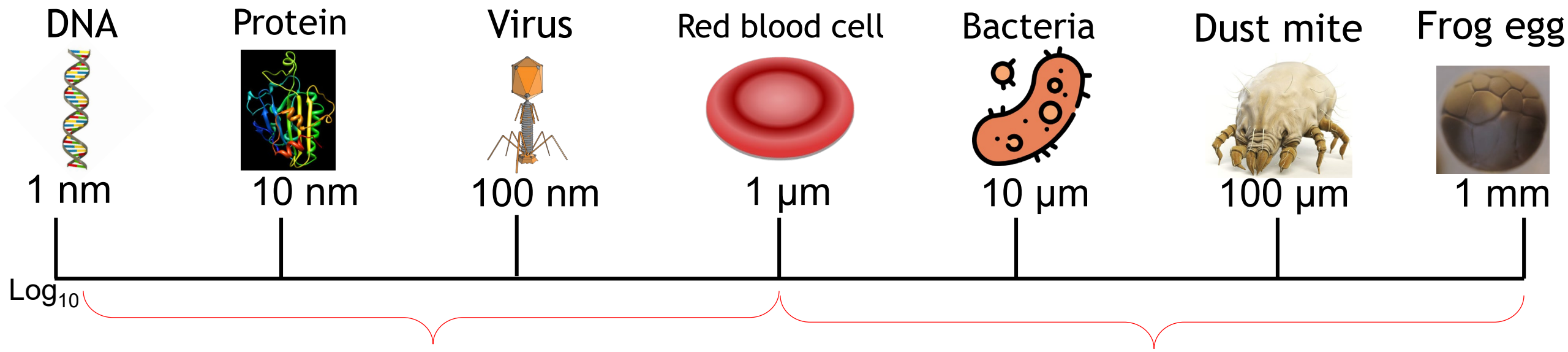
World Health Organization (2019)

Human health impacts: some medical evidence

Level of biological organization	Particle type and size	Effect
Macromolecules	PE 100 nm–30 µm PS 50 nm–4.7 µm PMMA 1 µm–2 µm PC 1 µm–55 µm	DNA damage, changes in gene and protein expression
Organelles*	PMMA 10 µm	more micronuclei
Cells	PS 20 nm–4.7 µm PE 300 nm–10 µm PMMA 2 µm–35 µm PS 20 nm–200 nm PS 60 nm–200 nm	cell clotting, necrosis, apoptosis, proliferation and loss of cell viability Oxidative stress Increased Ca ions
Tissues	PE 600 nm–21 µ, PMMA 1 µm–35 µm	inflammation and bone osteolysis
Organs	PMMA 1 µm–10 µm	lesions

FAO (2017)

Smaller particles are more toxic



Absorption/ Distribution	**< 100 nm** Access to organs, translocates blood-brain, placental barrier <7% absorption	**< 20 µm** Access to organs	**110 µm** Portal vein	**110-150 µm** lymph absorption <0.3%	**>150 µm** No absorption
Hazard	**20-200 nm** Apoptosis, necrosis, oxidative stress, cell clotting, neurotoxicity	**50nm - 1µm** DNA damage, gene/protein expression changes	**1-35 µm** Inflammation, lesions, bone osteolysis		

Data from FAO Report 2017

Human health impacts: extreme uncertainties

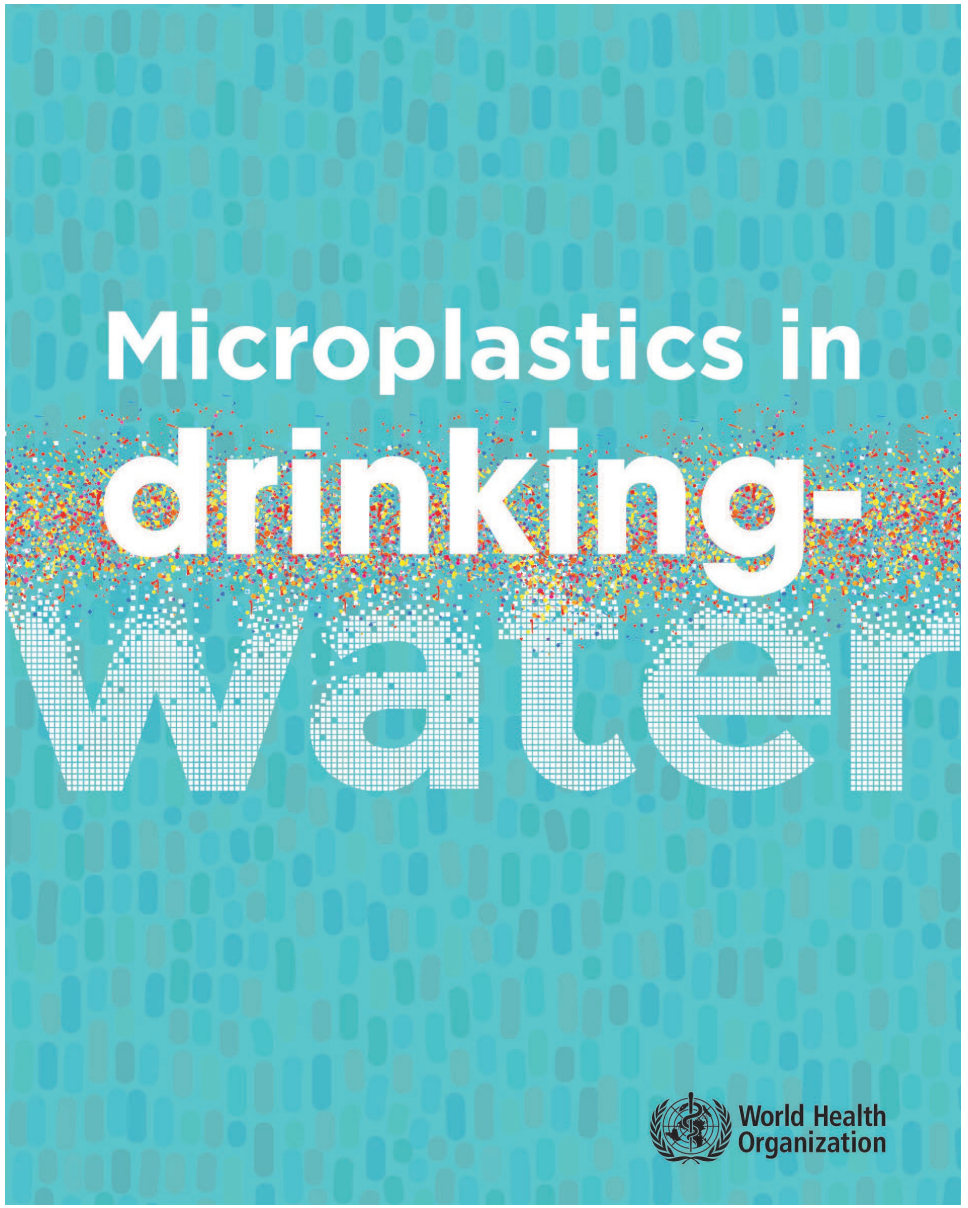
- **No epidemiological evidence** or **human studies** on ingested microplastics[1]
- Lab animal studies **inadequate** to inform human health risk assessment[1]
- 90-day dietary study on rats reveal **no effects** on blood parameters, organ weight, histopathology, mutagenicity (1-50 µm PET)[2,3]

[1]World Health Organization (2019)
[2]Merksi et al., *International Journal of Toxicology* (2008)
[3]Welle and Franze, *Food Additives & Contaminants* (2018)

Human health impacts: extreme uncertainties

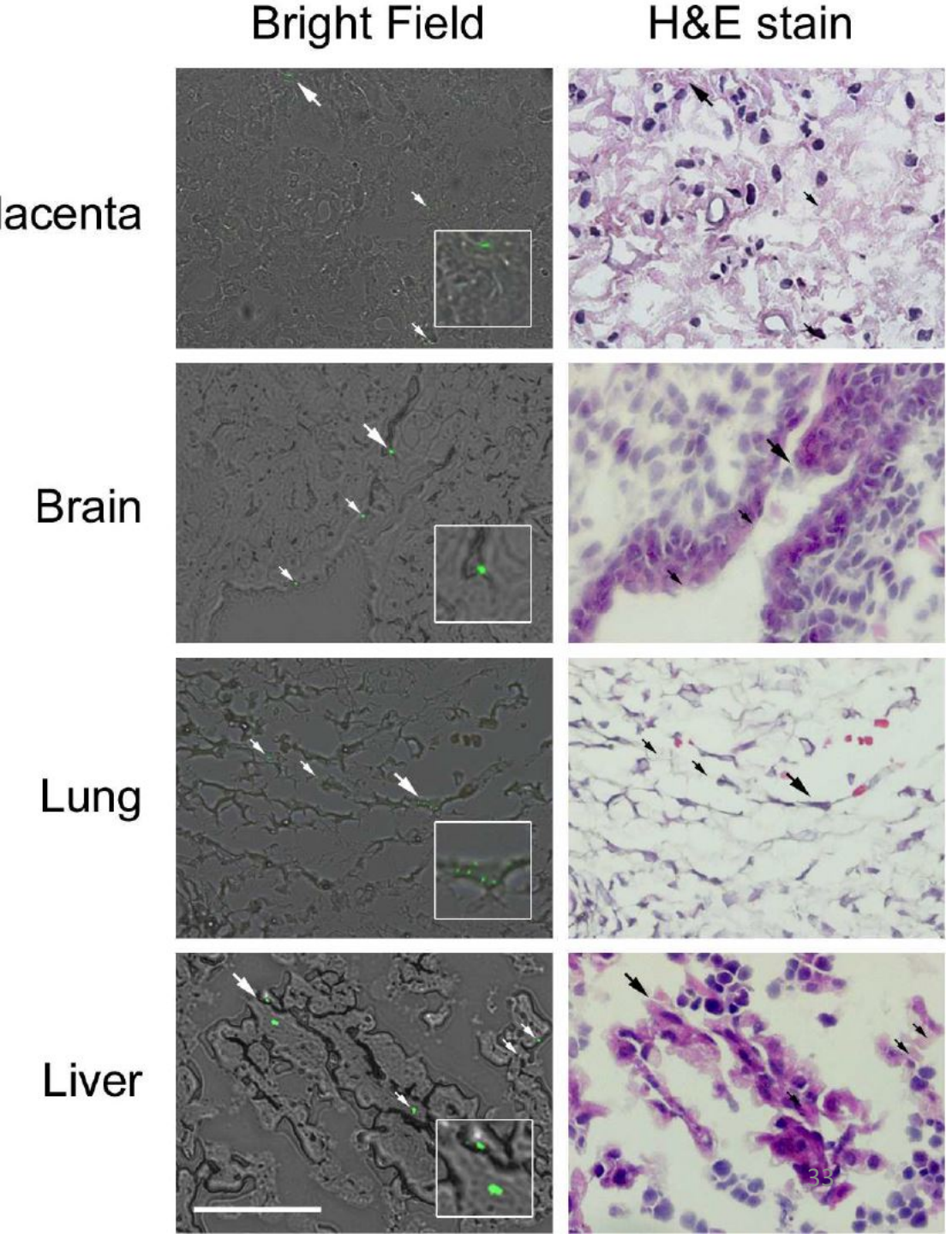
"Although there is **insufficient information** to draw firm conclusions on the toxicity related to the physical hazard of plastic particles, particularly the nano size particles, **no reliable information suggests it is a concern** through drinking-water exposure."

– World Health Organization (2019)



Nanoplastic crosses blood-brain and placental barrier

- Polystyrene particles (<500 nm) **cross placental barrier** and distribute into brain, lung, and liver[1]
- **Small nanoparticles** (<40nm) are cytotoxic, induce trophoblast cell apoptosis w/increased cleaved caspase 3 and reduce cell proliferation[1]



[1]Huang, *et al*, *Placenta*, 2015

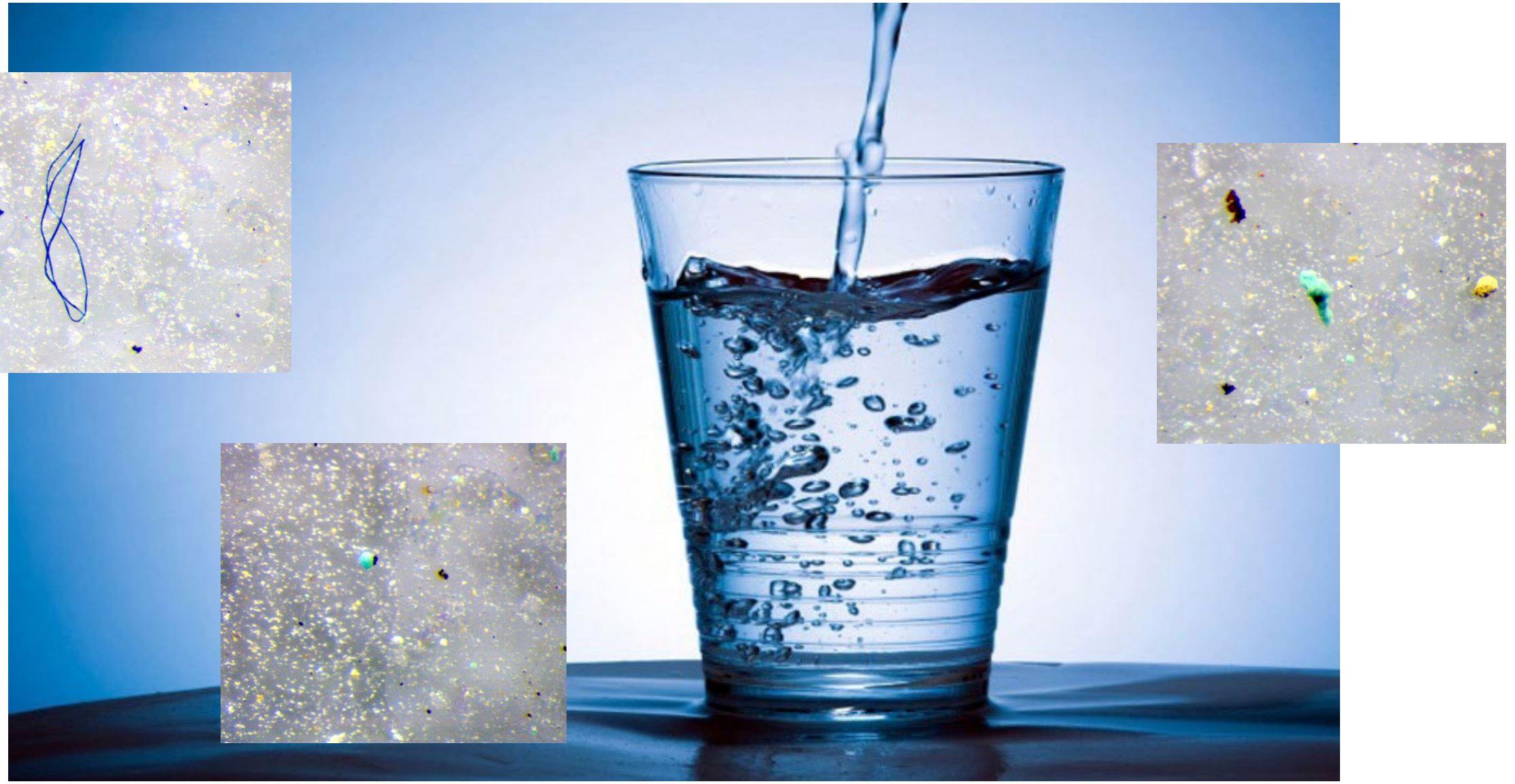
Senate Bill 1422 passed in 2018

Deadline

July 1,2021

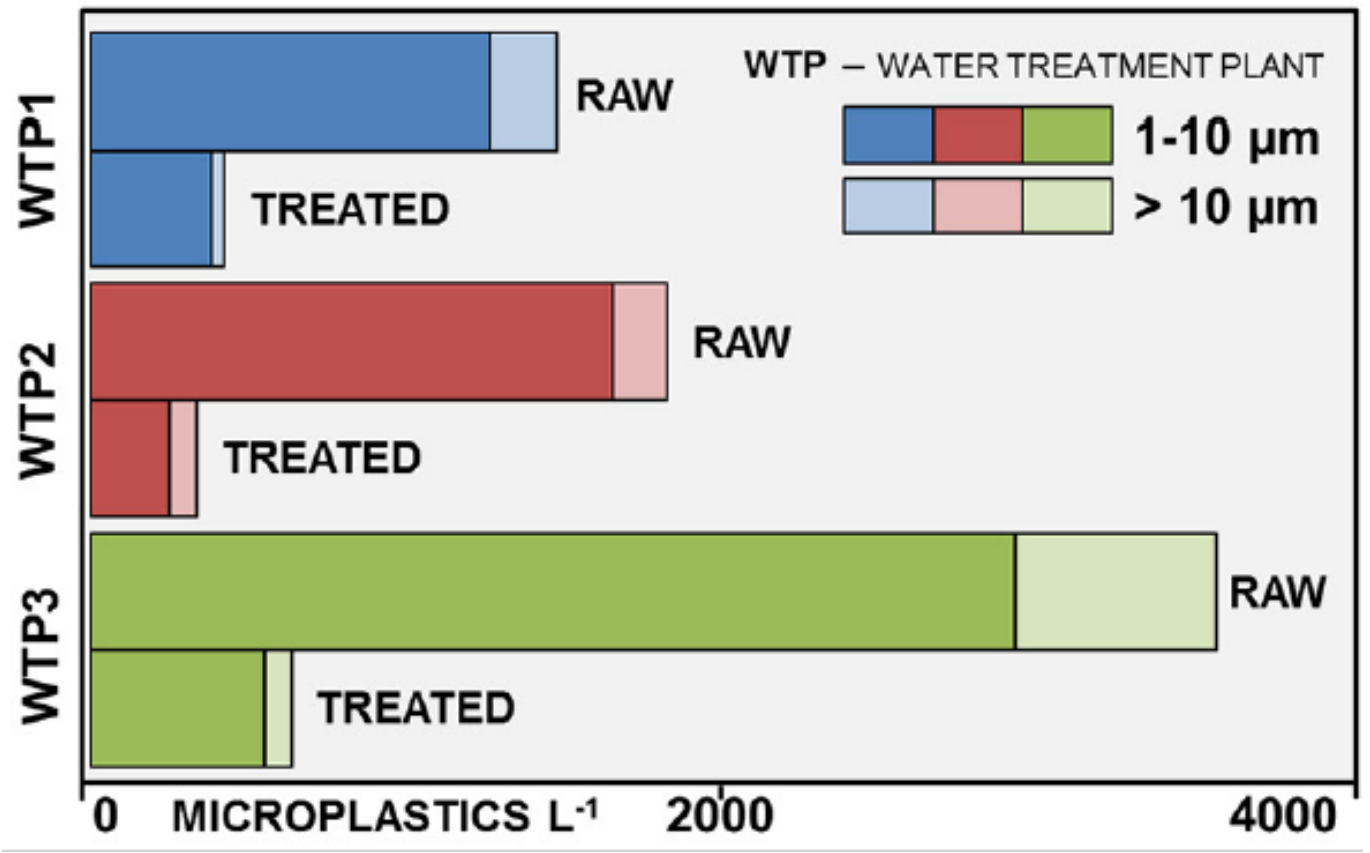
- Adopt requirements for four years of **testing** and **reporting** of microplastics in drinking water, including public disclosure of results

What types of drinking water contain microplastics?



Microplastics abundant in surface water

- **Small particles** dominate[1]
  - ~90% of particles 1-10 µm
  - Similar size to pathogens
- **Fibers** and **fragments** dominant[1,2]
- Flotation, sedimentation effective treatment options[1]

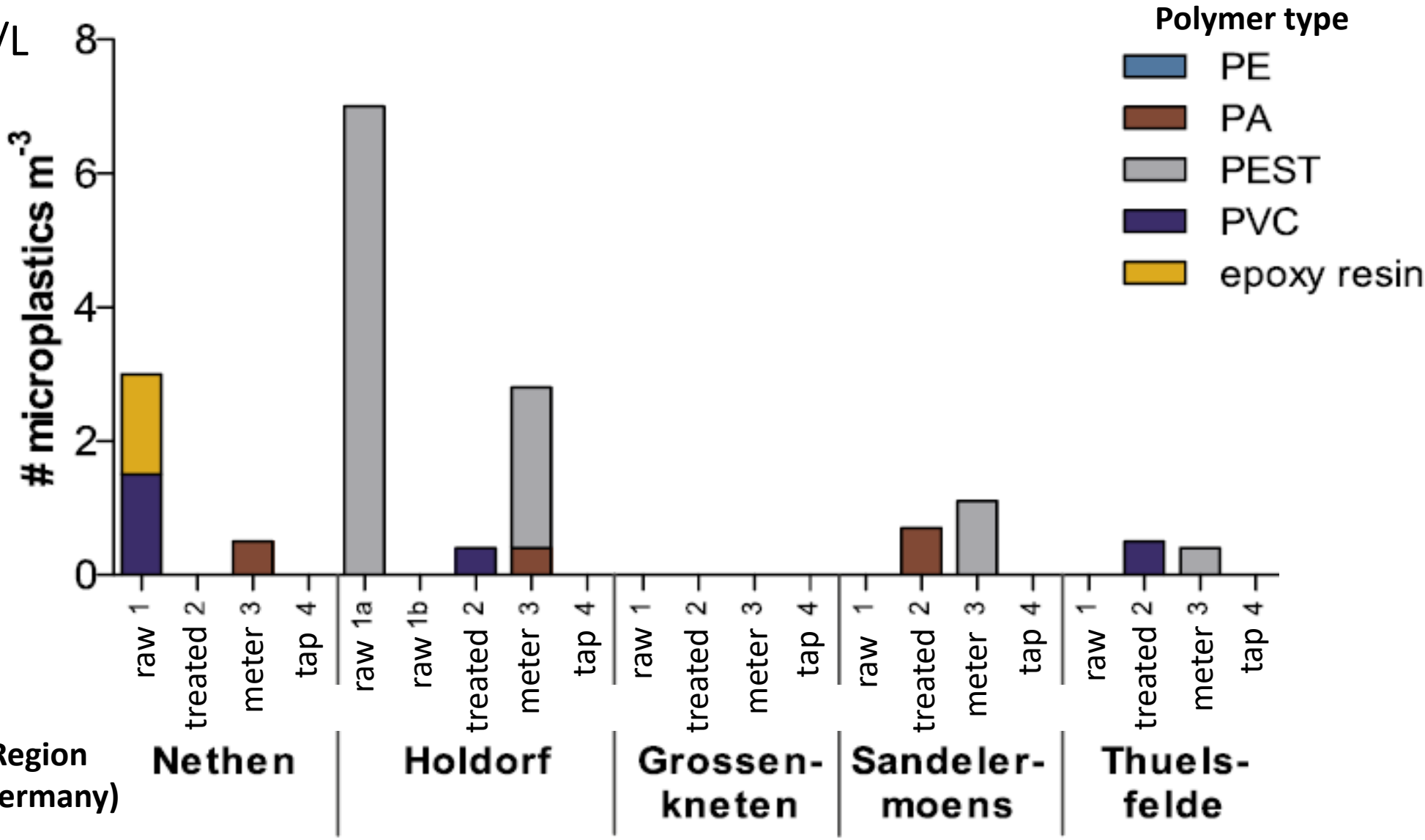


Figure[1]

[1]Pivokonsky, et al, *Science of The Total Environment,* 2018.
[2]Oßmann et al., *Water Research*, 2018

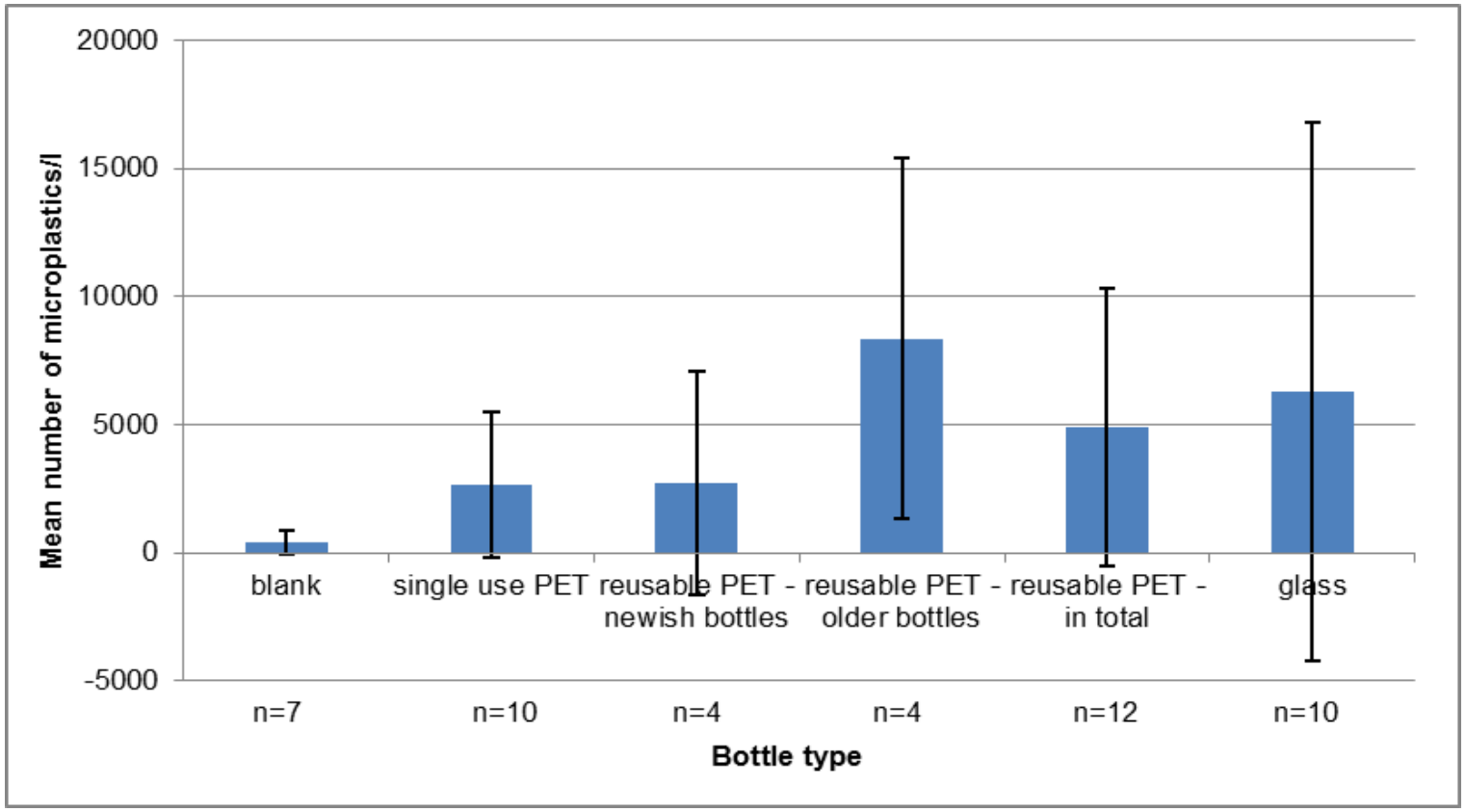
Microplastics low in groundwater

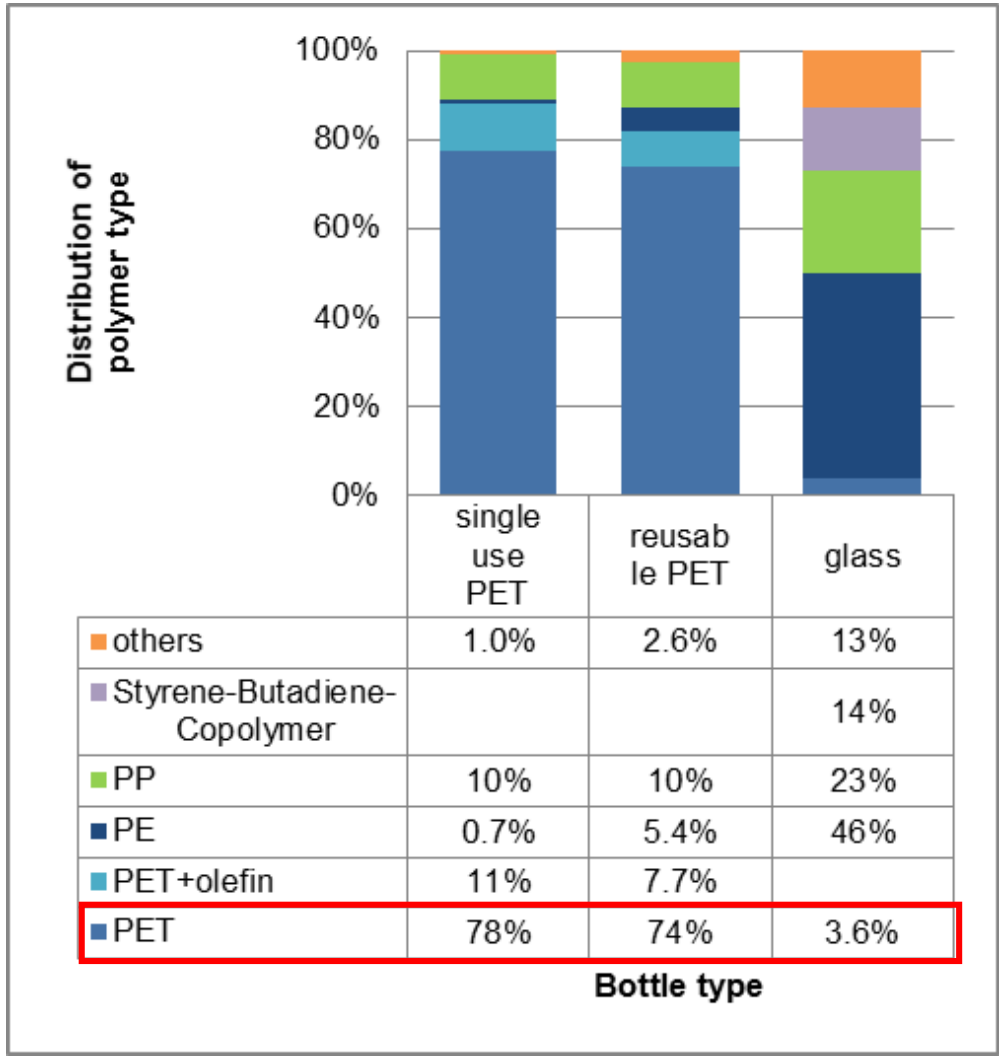
- **0-0.007** microplastics/L
- **20 µm** size limit



[1]Mintenig, et al, *Science of The Total Environment,* 2019

Microplastics found in bottled water





	single use PET	reusable PET	glass
others	1.0%	2.6%	13%
Styrene-Butadiene-Copolymer			14%
PP	10%	10%	23%
PE	0.7%	5.4%	46%
PET+olefin	11%	7.7%	
PET	78%	74%	3.6%

Oßmann et al., *Water Research*, 2018

Senate Bill 1422 passed in 2018

Deadline

July 1,2021

- **Accredit** laboratories

- ELAP will offer method(s) for **accreditation** by July, 2021
- **Quality Assurance** will be critically assessed (i.e. clean labs)
- **Proficiency Testing (PT)** samples will be utilized

Senate Bill 1422 passed in 2018

Deadline

July 1,2021

- Adopt **standard analytical method**(s)

- Contracting with the Southern California Coastal Water Research Project (SCCWRP) to **standardize method** in drinking water and source water and **interlaboratory validate**

Photo: Mandy Baker

Thank you!

Direct Inquiries to:
Scott.coffin@waterboards.ca.gov

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REGIONAL WATER QUALITY CONTROL BOARDS

@DrSCoffin